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The anterior bias in visual art: The case of images of animals

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Composition is an important topic in visual art. The literature suggests a bias for objects on the right side (Levy, 1976) and two additional biases with respect to positioning of objects within a rectangular frame: a Centre bias and an Inward bias (Palmer, Gardner, & Wickens, 2008). We analysed images of animals from three datasets of works of art: two datasets were from artists well known for their portraits of animals (Bewick, Stubbs) and the third was a medieval bestiary. There was no overall displacement of the subject to the right or to the left of the picture. However, we found a bias consisting of more space in front compared to behind the animal, consistent with Palmer at al.'s findings and with their definition of an Inward bias. Because our animals never face towards the centre we use the term Anterior bias. In addition, we found a modulation of this bias on the basis of the facing direction of the animal, consisting of a stronger Anterior bias for left-facing animals. This asymmetry may originate from a combination of an Anterior bias and a Right bias. Finally, with respect to size we found that the size of the animals predicted the proportion of the picture occupied, an effect known as "canonical size".

Keywords: Visual art; Left–right bias; Symmetry; Canonical size; Thomas Bewick.

Composition and balance are important topics in visual art and are often discussed by art historians and scholars (Arnheim, 1974; Wölfflin, 1941). Our study focuses on images of animals in which a single animal is the main subject of the picture. There are some clear advantages in this choice: (i) there are artists who have specialised in representation of animals, and therefore there are sizable datasets available; (ii) animals have a front and a back, and therefore a clear orientation; (iii) although simple, these are actual works of artists as opposed to images generated in a laboratory; (iv) within this category there is a considerable variety of subjects, for instance animals

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that are more or less exotic; (v) using animals avoids some important variables that need to be considered when analysing human portraits. For example, in most images of animals the sex of the specimen cannot be ascertained from the image. In addition, many human portraits have been created to flatter the sitter, thus adding a specific motivation that is absent in relation to animals.

Before describing our findings we discuss what is already known about composition. To address composition empirically presents some challenges, nevertheless within the literature on experimental aesthetics there have been several important contributions.

Symmetry and the centre of an image are often cited as relevant for beauty (Arnheim, 1982; Solso, 1994). Direct empirical evidence on the role of axes of symmetry of a frame comes from Palmer (1991). He asked observers to rate for "goodness of fit" images with a simple dot within a frame, and found higher scores along the vertical and horizontal axes, with a peak at the centre. Tyler (1998) found evidence that one of the eyes is usually located at the centre of a portrait. More specifically, in waist-up portraits of humans where the faces have both eyes visible, one eye is located along the midline of the picture. In a recent review McManus (2005) discusses both symmetry and asymmetries in visual art, but mainly in relation to the human face. He suggests that the right cheek is associated with the self and the left cheek by contrast is unlike the self.

Another important difference between the left and the right side of an image originates from the asymmetry of the human brain. In right-handed people evidence of asymmetry can emerge in simple tasks like the bisection of a line. Participants tend to mark the midpoint to the left of the true midpoint (pseudo-neglect: Jewell & McCourt, 2000). In addition to the line bisection task, when participants judge brightness, numerosity, or size of pairs of mirror-reversed stimuli they tend to select the stimulus with the relevant feature on the left as showing the dimension more strongly (Nicholls, Bradshaw, & Mattingley, 1999), and when comparing two objects participants tend to overestimate the extent of the object on the left (Charles, Sahraie, & McGeorge, 2007).

With respect to aesthetic preference, Levy (1976) found evidence that right-handed observers prefer photographs in which the more salient object is located to the right (the Right bias). Her interpretation is that because of the right hemisphere (left side of the visual field) advantage, pleasant images need to create balance by having more important objects on the right. Note that this is consistent with pseudo-neglect because a line bisected to the left has a longer segment to the right (i.e., a left bias in the bisection task is a right bias in terms of line length). The preference for objects on the right present in right-handed participants can reverse for left-handers (Levy, 1976; McLaughlin, 1986), which is consistent with known cerebral asymmetries.

Reading direction also plays a role, and participants who read from the left have been found to show the opposite bias (Nachson, Argaman, & Luria, 1999; but see Nicholls & Roberts, 2002).

Recently, Palmer et al. (2008) have studied aesthetic preference for the position of objects within a rectangular frame. Preferences were measured using three tasks: a two-alternative forced-choice judgement, the method of adjustment, and free choice in taking photographs. Although we were unaware of this study when our investigation started, it is highly relevant and we report the main findings here. Front-facing objects, such as a person facing towards the observer, were liked best when located in the centre of the frame (the Centre bias). Left-facing or right-facing objects, such as a cat seen from the side, were liked best when facing into the frame (the Inward bias). Specifically, Palmer et al. define the Inward bias as follows: "the direction the object faces (i.e., the direction from the object's center to its front) is the same as the direction from the object's center to the frame's center" (p. 425).

Interestingly, Palmer (1991) did not find higher goodness of fit for objects located to the right as opposed to the left. However, Palmer et al. (2008) report a weak preference for objects facing to the right, even when the object itself was at the centre of the frame. This is consistent with a bias to see motion from left to right (Gaffron, 1950), although in Palmer et al. the bias was the same for moving and non-moving objects (e.g., a teapot). It is also consistent with a bias to place salient objects on the right (the Right bias), given that the anterior (head) is the more salient feature of an elongated object (animal). However, to refer specifically to the preference for objects facing to the right we will use the term Right Facing bias.

A final bias that is worth citing with respect to composition derives from the rule of thirds. This rule is used by photographers and it states that the salient object should be placed at a location that is one-third the distance from the margin both horizontally and vertically (Clifton, 1973). It has also been suggested that this one-third rule is a rough approximation of the golden ratio (because 0.666 and 0.618 differ by less than 10%). McManus and Weatherby (1997) provided evidence that positioning of objects within a field for compositional purposes is, approximately at least, related to the golden section or to the rule of thirds. In this paper we will only focus on horizontal positioning and we will call this bias the One-third bias. Palmer et al. (2008) did not find evidence to support the existence of this bias in their study.

Figure 1 is a summary of the biases discussed in this introduction, divided in positional and directional biases. Some of them are incompatible, but they may coexist or combine in complex scenes. It is also interesting to note that some of them would not be retained in a mirror image of the original. This is obviously the case for the Right bias, which would turn into a Left bias. By contrast the Inward bias would not change because a right-facing object

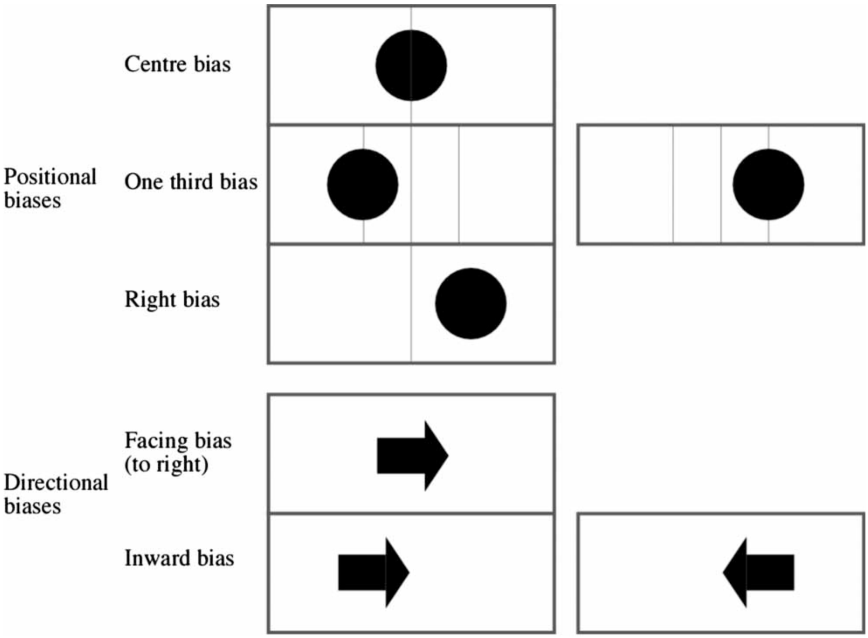

Figure 1. A summary of biases based on the literature, divided into Positional and Directional biases. From top: Centre bias (symmetry); One-third bias; Right bias; Facing bias to the right; Inward bias. The Centre bias is incompatible with the One third and the Right biases. However, one has to consider that in a complex scene multiple biases may play a role and affect different objects or parts within an object. The directional biases require objects with an orientation and the Inward bias could be described as having both a directional and a positional aspect.

with an inward bias would turn into a left-facing object with an inward bias. This is important because it has long been claimed that reversing images greatly affects their aesthetic qualities and their meaning (Wölfflin, 1941), and recently Bennett, Latto, Bertamini, Bianchi, and Minshull (2010) found evidence that reversing images of animals taken from the works of Thomas Bewick affected the expressiveness of these pictures.

DESCRIPTION OF THE THREE DATASETS

We selected Thomas Bewick (1753–1828) as an artist who produced a large number of images of animals. Bewick was mainly a wood engraver and prints were used to illustrate books like *The Fables of Aesop* (1818) and *A General History of Quadrupeds* (1790). Because they were intended as book illustrations their size is typically small, and there was no colour. One reason why we were attracted to Bewick was the fact that prints are normally a mirror image of the original drawing. However, it is clear from Bewick's writing that he thought carefully about composition and orientation, and in some cases went to the extra effort of reversing the copy twice, thus preserving the original orientation. In a sense, because of the engraving process, the attention of the artist is forced towards issues of left–right balance (Bennett et al., 2010). We chose *A General History of Quadrupeds* for the analysis because of the large number of images it contained ($N = 226$) and also because it is arguably the book that made Bewick famous. The vast majority of the images had a single animal with a clear orientation, and we excluded the few pictures in which that was not the case. This gave us a set of 218 images.[1]

The second dataset comes from another artist, also famous for his portraits of animals, the painter and engraver George Stubbs (1724–1806). In this case the images ($N = 142$) are mainly of horses and were taken from *George Stubbs: The Complete Engraved Works* (Lennox-Boyd, Dixon, & Clayton, 1989). These are prints, but they were produced in such a way as to respect the original orientation of the painting by the same artist. We selected only images in which a single animal was the central subject of the picture. This selection gave us a set of 71 images.[2]

Bewick and Stubbs specialised in images of animals. They lived at approximately the same time and in the same country (England). Moreover, Stubbs is known to have influenced Bewick. We therefore searched for a third dataset that would come from a fundamentally different source. We chose a bestiary (Bodleian Library MS 764, England, c.1240; Barber, 1999). Medieval bestiaries served an allegorical function in moral and religious instruction; they also served as social satire and as entertainment for clerical and secular audiences (Hassig, 1998). The images ($N = 130$) in the bestiary are in beautiful colour and are very expressive. They include familiar animals like horses and dogs, but also mythic beasts such as the monocerous (the artist's interpretation of a rhinoceros) and the chameleon (shown in Figure 2). The same selection criteria were used, giving a final set of 68 images.

[1] To carry out the measurements of the animals in *A General History of Quadrupeds* (1790) we used the 1970 reprint (Ward Lock, London) of the fifth edition (1807). The total of 226 images does not include the tailpieces that fill the space at the end of many chapters and are smaller in size and more diverse in subject. The 1807 edition of the book is available online (http://books.google.com/). More information on Bewick is available from the Bewick society (http://www.bewicksociety.org/).

[2] For the Stubbs dataset the images were taken from Part I of the Sotheby's Catalogue (reprinted by Stipple Publishing Ltd, 1989). Excluding anatomical drawings and repetitions there were 142 images of animals. Of these we selected 71 because the other 71 did not have a single main character (i.e., there were multiple dominant characters and each of them commanded a similar amount of space within the overall image).

Figure 2. Examples of animals from Bewick (left, sheep and elephant), from Stubbs (centre, horses), and from the bestiary (right, chameleon and bear). The top row shows animals facing to the right and the bottom row animals facing to the left. [To view this figure in colour, please visit the online version of this Journal.]

Two examples from each of the three datasets can be seen in Figure 2, one facing to the right and one facing to the left. Because we selected images in which a single animal is the main subject, this animal extends over both sides of the picture (i.e., the image straddles the midline). Thus we will use the term Anterior bias to refer to a special case of Inward bias; that is, the bias to have more space in front of the animal as opposed to behind it, without the animal facing towards the centre of the frame.

RESULTS

Bewick's animals

As can be seen in Figure 3, a majority of animals faced right ($N = 117$) rather than left ($N = 101$), but the difference was small and not significant based on a binomial test. It is possible that the similarity in numbers may come from an explicit decision to balance right- and left-facing images. Given that these images were intended for a book, and given that books have approximately the same number of left and right pages, this could perhaps be the reason. We analysed the association between orientation of the animal and the page of the book. Table 1 shows that animals facing either left or right were about equally likely to appear on a left or right page.

The position of each animal was measured by taking the horizontal distances between the animal and the left and right margins of the frame, as well as measuring the length of the animal itself, thus dividing the total

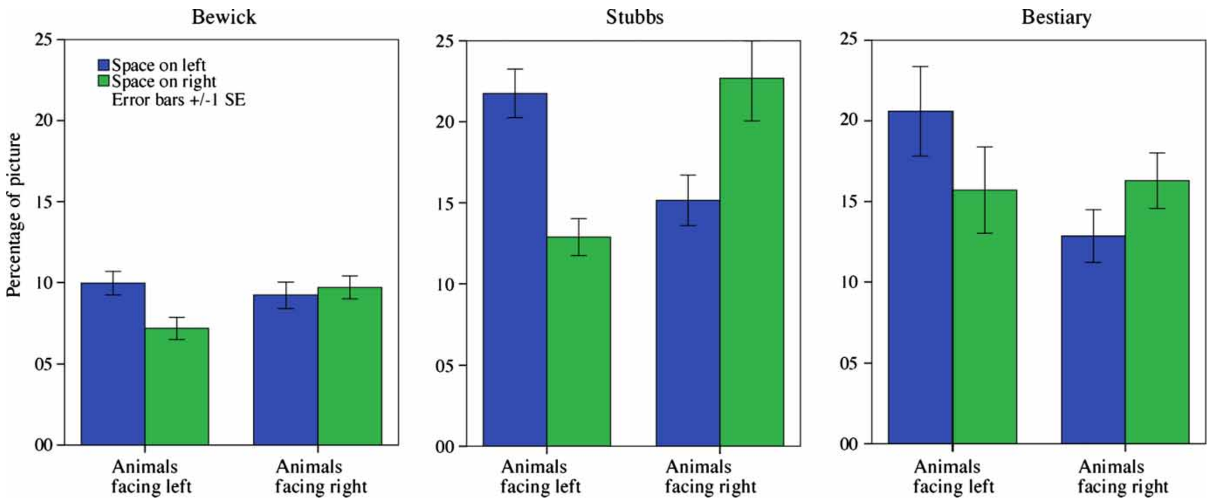

Figure 3. Distance from the left margin and from the right margin, measured as percentage of the total width of the picture, plotted separated for animals facing left and animals facing right. The Bewick, Stubbs, and Bestiary datasets are shown from left to right.

TABLE 1
Data from Bewick

	Left page	*Right page*	*Total*
Animals facing left	48	53	101
Animals facing right	62	55	117
Total	110	108	218

Data from Bewick's *A General History of Quadrupeds* (1790), showing the relationship between the direction the animal faces and the page in which it was printed. There is only a weak tendency for animals to face inwards, and it is not significant, $\chi^2(1) = 0.648$; *ns.*

width into three segments. The distances were measured from the farthest extremity at one end (i.e., the tail or heel) to the farthest extremity at the other end (i.e., the nose, horn, tongue, mane) of the body of the animal itself. Bridles, leashes, and other paraphernalia were ignored, as they were not deemed part of the animal. Where the animal was tangential to the border the measurement was recorded as zero. In some instances no clear frame was present so the margins were defined as the farthest point in the picture.

For right-facing animals the average distances from the left margin and the right margin were 6.97 mm and 7.24 mm. As a percentage of the width of the pictures these values are 9.2% and 9.7%. There was therefore more distance between the front of the animal and the margin of the picture compared to the distance between the back of the animal and the margin. For left-facing animals the average distances were 7.43 mm and 5.34 mm (10% and 7.2% of the width of the image). The reversed pattern means that it was again the distance in front of the animal that was greater.

We performed an ANOVA with percentage distance on the left and on the right as a repeated measure and orientation of the animal as factor. In the rest of the paper we will always report and analyse percentages, as this makes it easier to compare across images and across databases. Left and right distances did not differ overall, but there was an interaction with the orientation of the animal, $F(1, 216) = 7.50$, $p = .007$. The plot of this interaction in Figure 3 suggests the presence of an Anterior bias.

In addition to the Anterior bias we wanted to know if the bias was asymmetrical, and to this end we conducted two pre-planned tests. The difference was not significant for right-facing animals, $t(116) = -0.57$, $p = .570$, and was significant for left-facing animals, $t(100) = 3.33$, $p = .001$. Left-facing animals were placed to the right in the picture, as shown in Figure 3.

It may seem paradoxical that we have an asymmetrical Anterior bias (for left-facing animals) but no overall difference between left and right distances (no left side advantage). One issue to remember is that we do not have equal numbers for the two orientations. Instead we have 16 extra right-facing animals, which would themselves generate a right side advantage if we had a symmetrical Anterior bias.

Stubbs' animals

Approximately the same number of animals faced right ($N = 36$) and left ($N = 35$). Unlike Bewick's images, these pictures were not originally intended for publication in a book, so it is unlikely that there was an explicit strategy to balance the direction on the basis of the position on the page. Of the 71 images, 47 were images of horses (66%), and of the horses 22 faced right and 25 left. Bewick and Stubbs are therefore similar in having a weak or no bias for depicting the animal facing to the right.

Stubbs' animals sometimes had the head turned in the direction opposite the direction of the body. For right-facing animals there were four with the head turned to face directly towards the observer and two with the head facing to the left. For left-facing animals there were four with the head turned to face the observer and one with the head facing to the right. As these numbers are small we did not analyse these subsets separately.

Following the same steps used for Bewick, for each animal we measured the distance from the left and the right of the image. For right-facing animals the average distances from the left margin and the right margin were 15% and 23%. For left-facing animals the average distances were 22% and 13%. There was therefore more distance between the front of the animal and the margin of the picture compared to the distance between the back of the animal and the margin. The reversed pattern means that the distance anterior to the animal was greater.

We performed an ANOVA with percentage distance on the left and on the right as a repeated measure and orientation of the animal as factor. Left and right distances did not differ overall, but there was an interaction with the orientation of the animal, $F(1, 69) = 21.52$, $p = .001$. The plot of this interaction in Figure 3 supports the presence of an Anterior bias.

In addition to the Anterior bias we wanted to know if the bias was asymmetrical. The difference was not significant for right-facing animals using the 0.01 criterion, $t(35) = -2.36$, $p = .023$, and was significant for left-facing animals, $t(34) = 6.05$, $p = .001$. It was specifically the left-facing animals that were placed to the right in the picture, and the direction of the asymmetry visible in Figure 3 is the same as in Bewick.

The animals from works by Stubbs were reproduced larger than those from Bewick. This is not surprising as Bewick's animals are often small prints meant for pocket-size books. Stubbs, on the contrary, is famous for painting some impressive scenes of majestic horses. Within the larger frame of Stubbs' pictures the animals take up a smaller proportion of the total image compared to Bewick (Figure 3). Again, this is consistent with the more complex scene in which they are placed. Despite all these differences the pattern with respect to the position of the animal is remarkably similar: there is always more space anterior to the animal compared to the posterior space, and in addition there is a trend for this bias to be stronger for left-facing animals. Note also that the overall distances on the left and on the right were not different in either Bewick or Stubbs. There was therefore no support for an overall bias to position the animals on one side of the picture, irrespective of orientation.

Bestiary

The number of animals facing right ($N = 47$) was greater than the number of animals facing left ($N = 21$). This difference was significant based on a binomial test ($p < .01$). There was therefore some evidence of a Right Facing bias in this dataset, unlike the previous two.

Following the same steps used for Bewick, for each animal we measured the distance from the left and the right of the image. As a percentage of the width of the image, for right-facing animals the average distances from the left margin and the right margin were 13% and 16%. For left-facing animals the average distances were 19% and 15%. There was therefore more distance between the anterior of the animal and the margin of the picture compared to the distance between the posterior of the animal and the margin.

We performed an ANOVA with percentage distance on the left and on the right as a repeated measure and orientation of the animal as factor. Left and right distances did not differ overall, and there was only a non-significant trend for the interaction, $F(1, 66) = 3.08$, $p = .08$. Figure 3 is a plot of this interaction.

With respect to the asymmetry of the bias, the difference was not significant for right-facing animals and left-facing animals. The lack of a significant difference for right-facing animals is consistent with the results from the previous two datasets, but the lack of significance for left-facing animals is not. However, it is likely that there is a problem with power in this analysis. Not only was the sample size smaller compared to the previous databases ($N = 68$); in addition, within this sample the smaller group was the group of left-facing animals ($N = 21$), thus reducing the possibility of finding a significant Front bias even further. Nevertheless, the direction of the difference between the two groups is the same as that observed before, as shown in Figure 3. It was also observed that the space on the left side was larger for left-facing animals compared to right-facing animals, $t(66) = 2.52$, $p = .014$; this was not the case on the right side, $t(66) = -0.18$, *ns.*

Because of the small size of the sample, but also because of the greater variability in the images, both in terms of the scenes depicted and in terms of the type of animals, we performed an additional analysis based not on the distance but on the number of images in which one distance was greater than the other. In terms of numbers, for the right-facing animals 28 out of 47 had more space on the right (anterior), and 14 had more space on the left (posterior), with the remaining 5 having equal space right and left. For the left-facing animals, 12 out of 21 had more space on the left (anterior), and 8 had more space on the right (posterior), with the remaining 1 having equal space right and left. A Fisher exact test confirmed the association between orientation of the animal and which side had more space, $\chi^2(1) = 3.96$, $p = .046$. Thus this analysis lends support for the existence of an Anterior bias even in the Bestiary dataset.

Combined data

As a final step in the analysis we repeated the ANOVA with percentage distance on the left and on the right as a repeated measure and orientation of the animal as factor, and added dataset as a new factor. Unsurprisingly, this analysis confirmed the interaction between distance and orientation of the animal, $F(1, 351) = 36.04$, $p < .001$. This is the Anterior bias. More importantly, even with the increased power of the larger dataset we again failed to find any evidence that the subject of the picture, irrespective of its orientation, was located more to one or the other side with respect to the centre of the image, $F(1, 351) = 1.18$, *ns.* Moreover, this variable (distance from the left versus distance from the right) did not interact with dataset, $F(1, 351) = 0.05$, *ns.*

Because of the complex pattern of results, Figure 4 is an attempt to represent the results across the three databases together. What emerges is that there is always more space anterior to the animal (the Anterior bias), and in addition this bias is stronger for left-facing animals.

Canonical size

So far we have only analysed distances, but what about the size of the animals? In the combined database we checked with a *t* test whether left-facing animals and right-facing animals differed in size (as a percentage of picture width). There was no evidence of a difference, and the two values were 76% and 75% for left- and right-facing animals respectively.

In a recent study, Konkle and Oliva (in press) found that larger objects are drawn so as to take up a larger proportion of a frame compared to smaller objects (see also Linsen, Leyssen, Gardner, & Palmer, 2010). This tendency

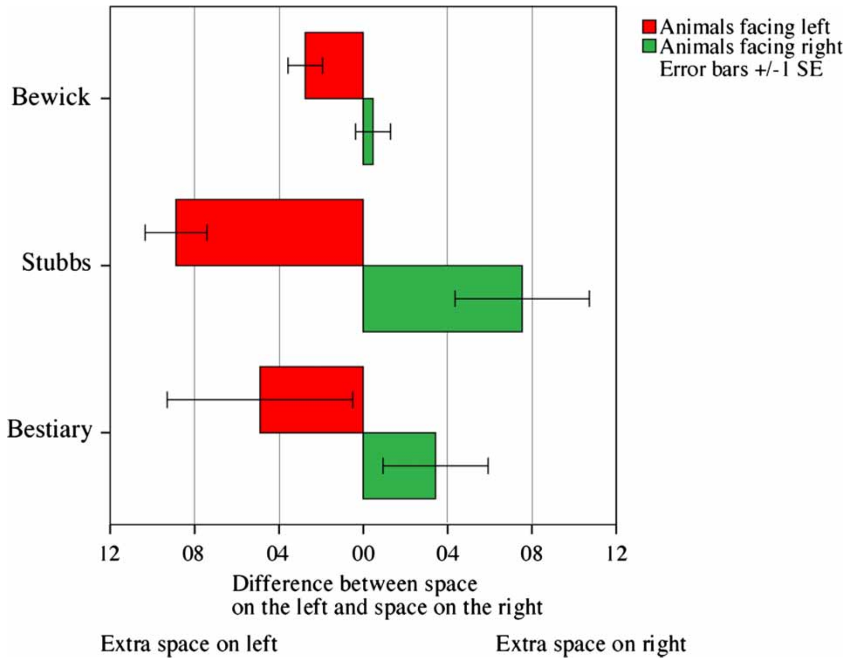

Figure 4. The difference between space on the left and space on the right, as a percentage of the width of the picture, is plotted separately for left- and right-facing animals, and for each of the three datasets.

has been named "canonical size". Our datasets allow a test of "canonical size" in real works of art. To perform this analysis we researched average length for each of the animals. In some cases this was easy; in other cases, like the few mythological animals in the bestiary, we based the size on the most similar existing animal. When average length was provided separately for males and females we averaged the two values. We performed this search based on the names, and therefore did not look at the actual images while doing this task. Next we compared physical size with the size of the animal in the image as a proportion of the frame.

Figure 5 shows the scatterplot of physical size (average length) and size in the picture separately for each of the three datasets. Linear regression lines are also shown. For Bewick the slope was positive and significant, $F(1, 216) = 5.27$, $p = .023$. On average for each additional metre in length of an animal the image of that animal covered an additional 2% of the picture. For Stubbs the slope was not significant, $F(1, 69) = 0.07$, *ns*. However, note that given the fact that the majority of animals in this database are horses, the flat line is what one would have predicted. For the Bestiary, despite the fact that this dataset is much smaller than Bewick's, the positive slope was

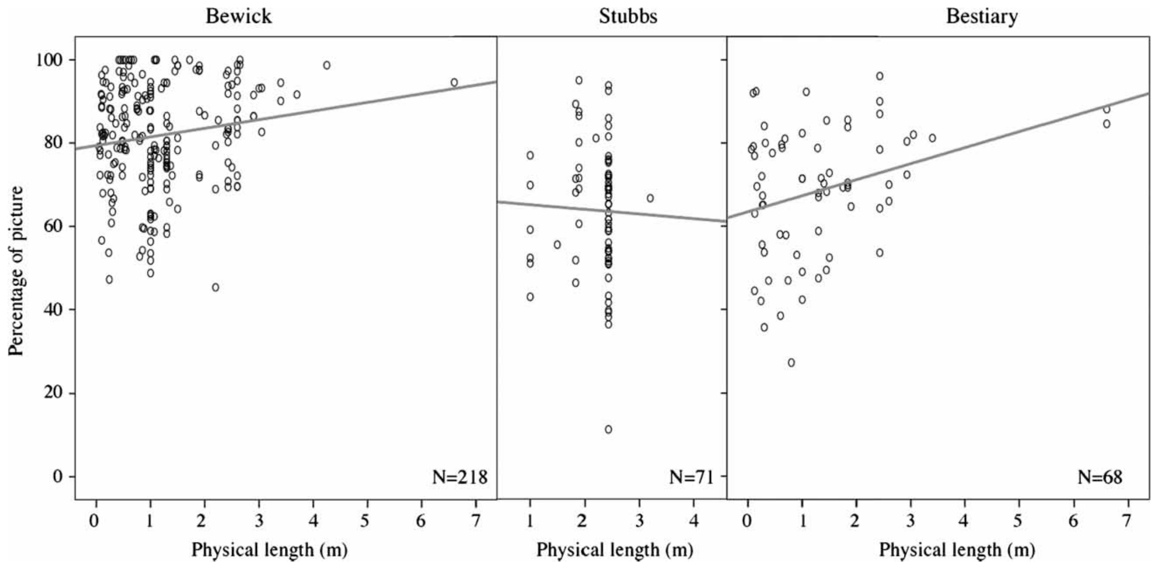

Figure 5. Percentage of the picture covered by the animal as a function of the average length of the animal. The grey lines are linear regressions separately for each dataset; slopes are greater than zero for Bewick and for the bestiary, but not for Stubbs. Note that Stubbs specialised in portraits of horses and therefore there is a narrow range of lengths in that dataset.

again significant, $F(1, 66) = 7.40$, $p = .008$. In this dataset, for each additional metre in length of an animal the image of that animal covered an additional 3.8% of the picture.

Closer inspection confirms that the pattern was remarkably solid. For instance, we looked at the lowest point in the Bewick graph. This outlier was a relatively long animal (2.2 metres) but its image occupied less than half of the picture horizontally. However, this happened to be a cameleopard, which we now call a giraffe (*Giraffa camelopardalis*). The aspect ratio of a giraffe is such that without an unusual choice of aspect ratio for the picture it would be impossible for the horizontal length of the animal to occupy a large proportion of the picture. In other words there was a logical explanation for this outlier.

In summary, the regression analysis supported the idea of canonical size (Konkle & Oliva, in press). Although testing canonical size was not the main aim of our study, these results show for the first time the existence of a canonical bias in actual works of art.

DISCUSSION

When expressing aesthetic judgements, people rate as more pleasant photographs in which the salient object is on the right side of the image (Beaumont, 1985; Levy, 1976). In the laboratory, observers prefer images with objects facing to the right (Facing bias), but a stronger bias is to have objects positioned so that there is more space in front of them compared to behind (Inward bias) (Palmer et al., 2008). Despite these asymmetric biases, there are also reasons to expect the centre of an image to be a preferred location for an object, and this may be called a Centre bias (Arnheim, 1982; Palmer et al., 2008).

We asked the question of where real artists place their subjects. To test that we selected a special case of images, those in which a single animal is the main subject. We analysed three datasets, based on pictures from Bewick (1753–1828), Stubbs (1724–1806), and the anonymous author of the Bestiary (thirteenth century).

We found a weak preference to represent animals facing towards the right, with a clear bias only in the Bestiary. We found no evidence for a bias to shift the subject of the picture towards one specific side in any of the three datasets (even when pooled for extra power). In the case of animals, therefore, it seems that the Centre bias is more important than the Right bias (Levy, 1976), with the latter only emerging in the fact that the head, as the more salient part of the picture, tends to be located on the right side (the right Facing bias). However, as mentioned, even this bias was only significant within the Bestiary dataset. Artists like Stubbs and Bewick might, for some reason, have chosen to produce similar number of images with animals facing left or right.

With respect to the One-third bias, we did not specifically test for it. However, if the body of an animal is centred at the 1/3 distance from the margin, and the animal is longer than 2/3 of the image, then some of it would be outside the picture. The average size of the animal as a percentage of the image was 82%, 64%, and 69%, for the Bewick, Stubbs, and Bestiary datasets respectively. Given this average size, and the fact that none of the animals in our data extended beyond the margin, it seems that the rule of thirds does not apply to the position of these animals. Note also that in Figure 4 the average extra space in front of an animal was 10% as a maximum. It is possible that the rule of thirds plays a role in more complex and cluttered images and not in individual portraits in which the subject is near the centre.

The clearest bias in the data was an Anterior bias: there was more space in front of the animals compared to the space behind the animal. This is a case of Inward bias as defined by Palmer et al. (2008) (see Figure 1). We use the term Anterior bias to refer specifically to the case in which the subject is not facing towards the centre of the frame. The animals in our datasets did not face towards the centre because their own body was placed in the middle of the image.

The results from Palmer et al. (2008) come from a laboratory study. More recent work by Gardner, Fowlkes, Nothelfer, and Palmer (2008) has confirmed the inward bias in a database of stock photography, and for the first time we have found evidence for such bias from actual works of art. It appears, therefore, that this is a widespread bias.

Apart from the analysis of the position of the animals, we also analysed the size of the animals in the pictures as a proportion of the total horizontal distance. We found that the average size of a particular species predicted the proportion of the picture occupied by its image, an effect known as "canonical size" but not documented before in works of art (Konkle & Oliva, in press).

Returning now to the analysis of position, in addition to the Anterior bias we found an asymmetry such that this Anterior bias was stronger (or confined to) left-facing animals. To our knowledge this asymmetry has never been reported before, but we found evidence for it in each of the three datasets. We therefore need to discuss its possible origin.

We suggest that an asymmetry in the size of the Anterior bias may originate from a bias to position animals slightly to the right, and this bias combines with the Front bias so as to produce images in which right-facing animals are almost centred, whereas left-facing animals are shifted more by the combined effect of the two biases. In this sense the asymmetry is evidence of a Right bias, for which there is a neurophysiological explanation (Levy, 1976). However, note that the Anterior bias was the strongest of the findings in our analysis, and is clearly illustrated in Figure 3 and also in Figure 4. A bias to position animals to the right, on the other hand, would have to be much smaller, and there was no evidence of such overall bias for the position of the animal across our three datasets. With a matched number of animals facing left and right, the asymmetry in the Anterior bias would also produce a Right bias, but there was a slightly larger number of right-facing animals in our dataset. The implication is that for a full analysis and explanation of compositional biases it is critical that both position and orientation of the subject are taken into account.

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